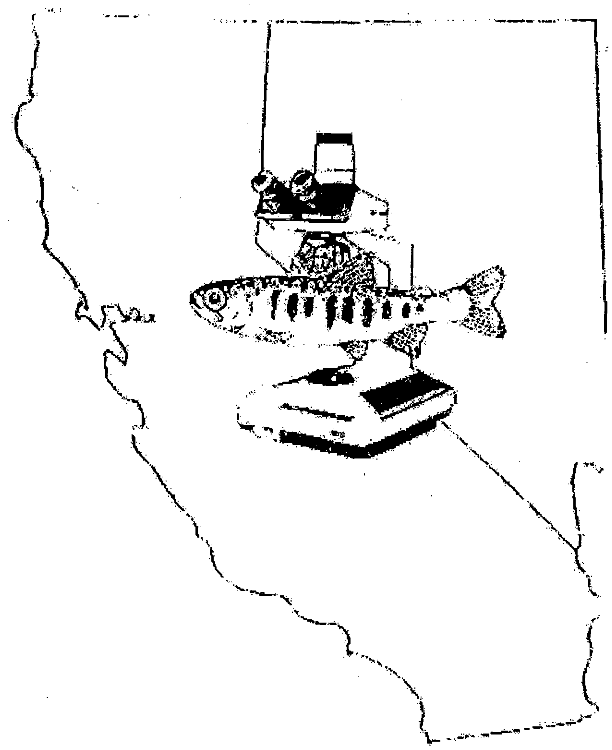
FY98 Investigational Report :

DIAGNOSTIC EVALUATION OF MORIBUND JUVENILE SALMONIDS IN THE TRINITY AND KLAMATH RIVERS (JUNE - SEPTEMBER 1998).



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Summary: Columnaris and bacterial septicemia were the major disease problems affecting the health and survival of juvenile salmonids in the lower Trinity and Klamath Rivers in 1998. Bacterial infections from *Flavobacterium columnare* and *Aeromonas / Pseudomonas* species were isolated most frequently from sick chinook. Water temperature in excess of 20 ^{0}Celcius and dissolved oxygen levels below 7 milligram/Liter occurred for extended periods during the June 15th to September 1st study period and are believed to have contributed to the presence of disease. A low estimate of 240,000 natural and hatchery origin chinook perished due to disease prior to their entry into the estuary. We recommend that data on dissolved oxygen and water temperature be collected in the lower Trinity and Klamath Rivers because of their importance to fish health. Additionally, controlled experiments investigating the relationship between Klamath basin pathogens, water quality, and the development of fish disease should be conducted.

The correct citation for this report is:

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Background
The US Fish and Wildlife Service, California - Nevada Fish Health Center has been an active partner in monitoring health and physiology of outmigrant chinook smolts in the Trinity and Klamath Rivers since 1991. In 1995, a high incidence of severe infection by the enteric parasite *Ceratomyxa shasta* was observed in moribund chinook smolts captured in the Klamath River (Foott, in preparation). Previous Fish Health Center (1991-1996) studies of Trinity and Klamath river smolts have also detected other important infectious agents including a presporogonic form of an unidentified myxozoan parasite (possible *Sphaerospora, Myxidium,* or *Chloromyxum sp.*), a metacercarial stage of the trematode parasite *Nanophyetus salmincola,* and infection with *Renibacterium salmoninarum* (the agent which causes bacterial kidney disease). Another abnormality observed in summer outmigrant chinook in the Klamath River is inflammation of the pancreatic tissue and/or associated adipose tissue.

Objective and General Methods The project objectives were to document the magnitude and causes of significant mortality and morbidity in lower Klamath Basin juvenile salmonids (including the lower Trinity River and Klamath Estuary). The study period of June - September 1998 was selected to cover the summer outmigration of juvenile chinook salmon. Site-specific environmental data (temperature, dissolved oxygen, river flow) was also collected or obtained through other sources for possible correlation with disease incidence.

Several species of hatchery and natural fish captured at five sites in the lower Klamath Basin were evaluated for general health. Fish were sampled from rotary screw trap, beach seining, and boat electrofishing operations performed by the US Fish and Wildlife Service, Coastal California Fish and Wildlife Office (CCFWO) and cooperating agencies within the basin (Table 1). Sampling began June 22, 1998 and concluded after 11 weeks on September 1, 1998. Only moribund fish exhibiting clinical signs of disease and pathogen infection were sampled at any particular site. During each site visit, one to 20 lethargic or sick looking fish were examined and sampled for microbiological tests. One to four fish were euthanized at a time, measured for fork length, and examined for external and internal organosomatic characteristics (Goede and Barton 1987, Foott 1990). A numeric "severity" score (0,1,2,3) was assigned to each tissue with 0 equal to normal and 3 representing severe abnormality. The fish's tissue scores were then analyzed for inconsistencies within the sample and compared to scores from what is considered normal (See appendix 1).

If the gill, spleen, or kidney looked abnormal, imprints were made for bacterial diagnosis. Additionally, kidney or spleen tissue were inoculated onto bacterial media (BHIA and/or TYE) for later laboratory identification. Viral samples from the kidney were collected from moribund chinook kidneys and spleen. Posterior kidney was frozen for metacercaria counts using a dissection microscope. Trematode counts were ranked low, medium and high based on 1991-1997 results (Low=1-9, Medium=10-24, and High=> 25 metacercaria in a 100mm Chinook smolt. Category cutoffs are roughly equivalent to 500 and 1000 metacercaria / gram KD , respectively). Bacterial colonies were identified using standard morphological, microscopic, and biochemical identification methods. If Bacterial Kidney Disease was suspect, kidney imprints were analyzed by the direct flourescent antibody technique (DFAT) for the causative agent *Renibacterium salmoninarum*. For histology, the intestinal tract, kidney, gill, and liver were removed and fixed in Davidson's fixative (Humanson 1979), processed for 5μm paraffin sections, and stained with hemotoxylin and eosin. Tissue abnormalities and parasite infections were evaluated by light microscopy. Rotary screw trap and estuary crews also recorded the number of fish with external signs of disease.

Table 1. Sample site, operators and global positioning system coordinates.

Sample site	Operator	Global positioning system coordinates
Willow Creek Trap-mainstem Trinity River (rkm = 34)	US Fish and Wildlife Service, Coastal California Fish and Wildlife Office	N40:59:12.3 W123:38:5.77, Elevation ~320 ft.
Weitchpec Trinity River trap (rkm 0)	Yurok Tribal Fisheries, Klamath, CA	N41:11:04.77, W123:42:22.39, Elev172 ft (+-39ft)
Omagar Creek Trap-mainstem Klamath River (rkm 16.9)	Yurok Tribal Fisheries, Klamath, CA	N41:29:19.12, W123:57:49.17, Elevation 6ft (+-45)
Big Bar Trap-mainstem Klamath River (rkm = 81)	US Fish and Wildlife Service and Karuk Tribal Fisheries, Somes Bar	N41:15:2.87 W123:38:21.87 Elevation ~400ft.
Klamath Estuary (rkm 0)	California Department of Fish and Game, Arcata, CA	N41:32:20.38, W124:04:31.5, Elev20ft (+-12ft)

Saltwater Challenge - A 72 hour saltwater challenge was performed on August 27, 1998 to see if a relationship existed between the osmoregulatory ability of challenged chinook and the intensity of a myxosporidian kidney infection. Myxosporidian kidney infection was quite common in Klamath Estuary chinook in 1997 and was associated with glomerulonephritis. Fifteen juvenile chinook were captured alive in the upper estuary by boat electroshocking, transported to the CCFWO in an aerated bucket of cooled (17^{0}C) estuary water, and placed in a 106 liter aquarium containing aerated, 27 ppt saltwater (INSTANT OCEAN ™) at 17^{0}C. After 72 hours, surviving fish were measured, weighed, bled for a plasma sodium sample and the kidney fixed for histological examination.

To estimate the number of mortalities in the outmigrant chinook population associated with disease, the mortality rates of chinook at the Trinity and Klamath river rotary screw traps were used to estimate the hatchery and natural juvenile chinook population mortality. Trap mortality can be related to a number of factors such as handling stress, high fish density, and disease. To generate a hatchery origin juvenile chinook mortality estimate, the percent mortality in the rotary screw trap catch was multiplied by the total hatchery release figure to generate a total population-wide mortality estimate. For the natural origin juvenile chinook mortality estimate, the proportion of adipose fin clipped chinook to unmarked chinook in the hatchery release group was compared to the proportion recovered in the rotary screw trap. The difference in proportions is the natural component (less approx. 3000 marked Trinity River natural chinook). Using this proportion, the natural origin percentage of the catch can be predicted. This percentage multiplied by the hatchery release number produces a natural chinook population figure which can be multiplied by the trap mortality rates. Four assumptions are detailed which may affect population mortality estimates. They are:

1) the primary pathogens isolated in this study are the same pathogens responsible for the majority of the mortality at the traps.

2) Klamath and Trinity river rotary screw trap mortality rates are equal to the mortality rate occurring in the migrating chinook population.. In other words, there are no differences in the occurrence of dead chinook in the trap's catch and the occurrence of dead chinook in the population.

3) the occurrence of adipose fin clipped chinook in the trap is equal to the rate of occurrence in the population.

4) adipose fin clipped hatchery and natural juvenile chinook have equal mortality rates and there is no behavior differences resulting from their marking which affects their survival.

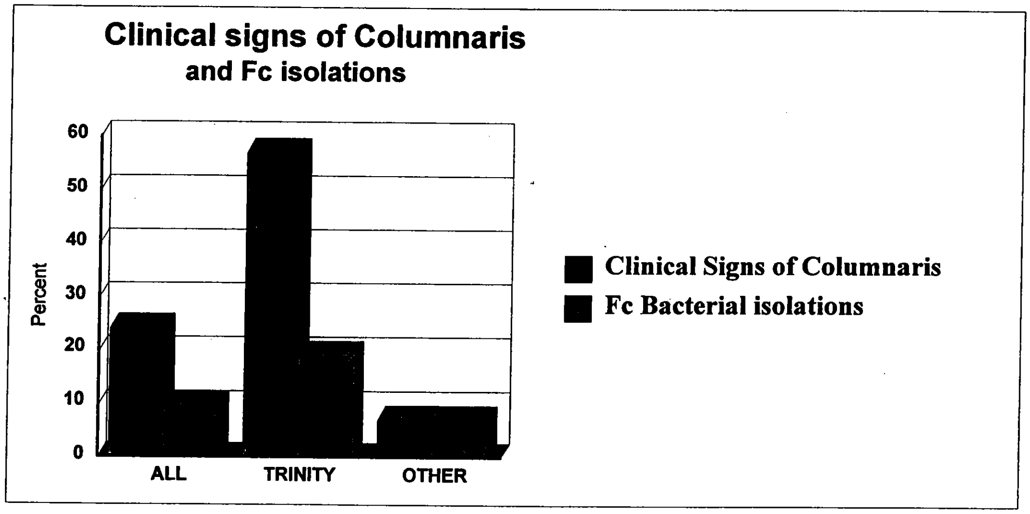
Results

Two hundred seven fish were examined, of which 193 were chinook salmon (*Oncorhynchus tshawytscha*). Other fish species sampled include sockeye salmon (kokanee?) (*Oncorhynchus nerka*), steelhead/rainbow (*Oncorhynchus mykiss*) and cutthroat (*Oncorhynchus clarki*) trout, ammocoete larvae of Pacific lamprey (*Lampetra tridentata*), Klamath small scale sucker (*Catostomas rimiculus*), and speckled dace (*Rhynichthys osculus*). Analysis of data regarding species other than chinook is limited since they were far less prominant in the data compared to chinook. Additionally, since only ten fish were sampled at the Trinity River Weitchpec screw trap and because it is relatively close to the Willow Creek mainstem Trinity River trap, the findings from this trap are usually lumped together with the Trinity River Willow Creek rotary screw trap.

Bacteria Results - A *Flavobacterium* species (presumably *Flavobacterium columnare*) was associated with external lesions resembling Columnaris disease. This disease was observed in a large portion of the moribund fish examined in this study. While only isolated in culture from 10% (8 out of 78) of all bacterial samples taken, its clinical signs of necrotic gill and yellowish lower jaw were observed in 24% (34 out of 139) of the fish examined in the study. Symptoms of columnaris were noted in 57% (25 out of 44) of samples from the Trinity River Willow Creek trap. Furthermore, bacterial samples from this location produced *F. columnare* isolates in 6 out of 32 samples (18%) (see chart 1). Average daily water temperatures on the lower Trinity and Klamath Rivers ranged between 12.6 and 25.4 degrees Celcius during the study period (measured every two hours by Onset Dataloggers at Trinity River (rkm 34) and Klamath River (rkm 81)). The most frequently occurring daily average temperatures during the study period were 23.5 and 21.0 for the Klamath and Trinity Rivers respectively.

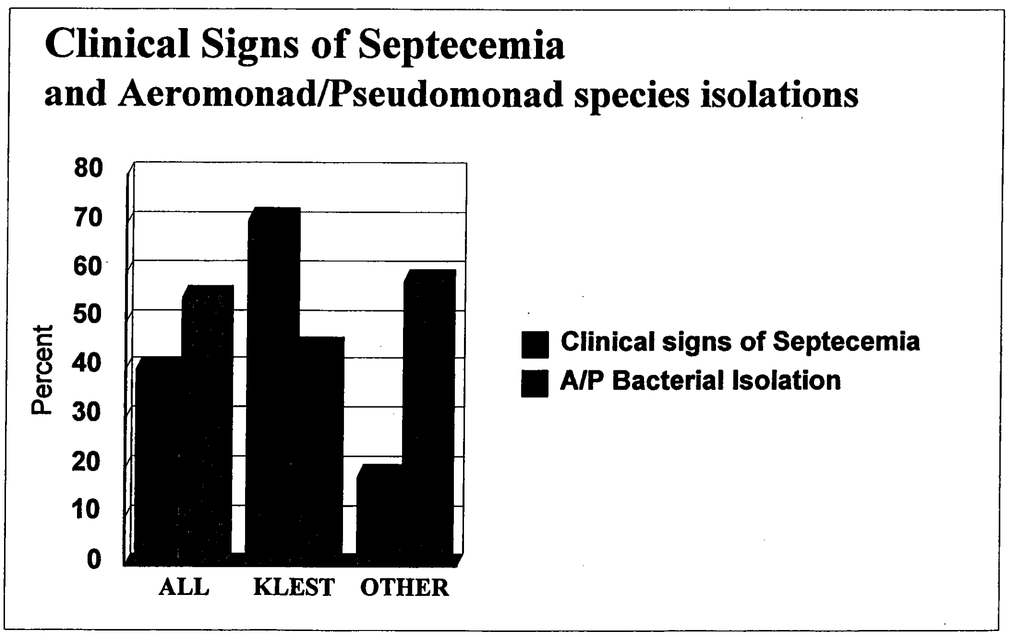
Columnaris disease is generally lethal and tends to attack fish at relatively high water temperatures. Holt et al. (1975) demonstrated that *F. columnare* infection at temperatures above 17.8 °C resulted in over 50% mortality in juvenile chinook. At 23.3 °C, the challenged chinook incurred a 92 % mortality. Field studies in the Columbia River also support the relationship of elevated water temperature and columnaris. Pacha and Ordal (1970) reported a dramatic increase in the incidence of columnaris in adult sockeye salmon during times of high water temperatures. The potential for *F. columnare* to inflict disease in the lower Klamath Basin is high given that these reported water temperatures are a common feature of the basin in late spring and summer.

Chart 1. Percent of moribund fish examined with clinical signs of columnaris disease and of bacterial sample isolation of *Flavobacterium columnare* (Fc) from all sites (ALL), Trinity River rotary screw traps (TRINITY), or sites other than the Trinity River s (OTHER). The number of fish examined for clinical signs of columnaris from ALL (n=139), TRINITY (n=44), and OTHER sites (n=95). The number of bacterial samples taken from fish at ALL, TRINITY, and OTHER sites are N=78 and N=32, and N=46 respectively.



Systemic bacterial infections (septicemia), characterized by subcutaneous hemorrhaging at the fin bases, abdomen, and mouth were also common disease symptoms seen in sick fish. Clinical signs of septicemia were seen in 40% (62 out 155) of the all sick fish examined (chart 2). This lesion was quite prevalent in the Klamath Estuary (71% , 37 out of 52 fish examined). Fifty-five percent (43 out of 78) of the bacteria cultured from sick fish at all sites were either *Aeromonas* and *Pseudomonas* species (A/P) or *Vibrio* type bacteria. Since *vibrio* type bacteria are biochemically similar to A/P and cause similar symptoms, a subset of theses cultures (6 out of 78) was characterized by the California-Nevada Fish Health Center using antibiotic sensitivity tests. No samples were identified as *vibrio* spp. Furthermore, *vibrio* species of bacteria do not grow well on aqueous bacterial media without 1.5-2.0 % sodium chloride (Warren, 1991). Since, no sodium chloride was used in bacterial media for this study, vibrio is assumed to be absent from any of our A/P isolates. Nevertheless, the possibility remains that A/P isolates was misidentified. In the Klamath estuary sample group, A/P isolations occurred in 44% (8 out of 18) of the bacterial samples. At sites other than the Klamath estuary, it was common (58%) to isolate A/P bacteria from kidney samples, however, only 18 % of the sampled fish from these other sites showed clinical signs of septicemia. This data indicates most of the fish examined had sub-clinical A/P infections except in the Klamath Estuary. *Aeromonas* and *Pseudomonas* pathogens are opportunistic and ubiquitous in soil and water. The mortality rate due to A/P septicemia infections is unknown, but it is likely that survival was affected by this infection. *Aeromonas hydrophila*, *Aeromonas punctata*, and *Pseudomonas fluorescens* are the species assumed to be responsible for these types of infection.

Chart 2. Percent of examined sick fish with clinical signs of septicemia and bacterial samples resulting in isolation of *Aeromonas/Pseudomonas* species . Number of fish with clinical signs from all sites (ALL, n= 155), Klamath estuary (KLEST, n=52), all other non-estuary sites (OTHER, n=103). Bacterial samples from all sites, Klamath estuary, and other non-estuary sites were n=78, n=18, and n=60, respectively.



Renibacterium salmoninarum The bacteria causing bacterial kidney disease was visualized by direct fluorescent antibody technique (DFAT) from only four out of 14 chinook kidney samples. No other isolations of this pathogen were made and like recent years, it was not considered a problem in the Klamath Basin in 1998.

Parasites Results- A metacercarial stage of a trematode parasite (presumptive identification *Nanophyetus salmincola*) was detected in squashes of kidney tissue and histological samples of gill and kidney taken from all sample groups. Trematode infections of gill or kidney were judged not to be a significant health problem (few "high"intensity infections) during 1998 (see chart 3) when compared to 1991-1994 collections. Like previous years, a higher percentage of Trinity River chinook (and one steelhead) had "medium" and "high" kidney metacercaria infections compared to Klamath River chinook. Histological analysis revealed metacercaria in 47% of all the sampled gills and 58% of the gills from the Klamath River at the Big Bar Rotary screw trap (see chart 4). For some reason, a higher percentage of gill metacercaria infections occurred in Klamath fish rather than Trinity origin chinook. In contrast, a higher number of kidney metacercaria infections were detected in the Trinity chinook.

Average daily flow in the Trinity and Klamath Rivers in 1998 was the highest or second highest since 1988 (see appendix 2). We theorized that slower flows would result in higher numbers of infected intermediate hosts (*Juga* sp. snail). A reduction in scouring flow would have a positive impact on snail survival, distribution, and age composition. Older snails have a higher incidence of infection and more parasites than younger snails. Any ecological condition which favors older or more snails will likely result in higher infection rates in smolts. Since flows were above average during 1998, snail density and infections rates were probably not significant to smolt survival. For more information on the metacercarial infections (see appendix 3).

Chart 3. Percentage of smolts with kidney metacercarial infection and relative intensity of infection from all (ALL) samples, all Trinity River (TR) samples , Klamath River samples at Big Bar (KLBBT) and Omagar Creek (KLOC) trap sites, and the Klamath Estuary (KLEST). The infection intensity is based on the number of metacercaria per kidney that fall into corresponding categories (Low = 1-9, Medium = 10-24, High => 25).

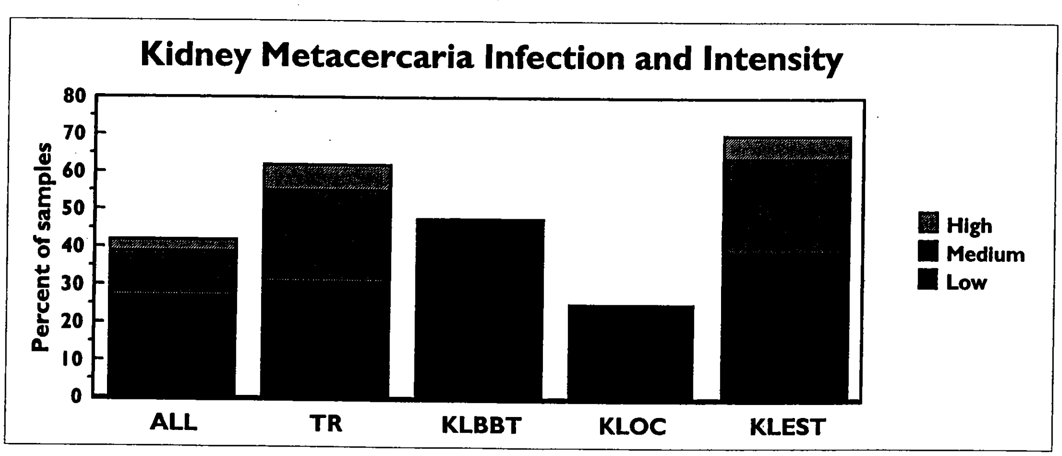
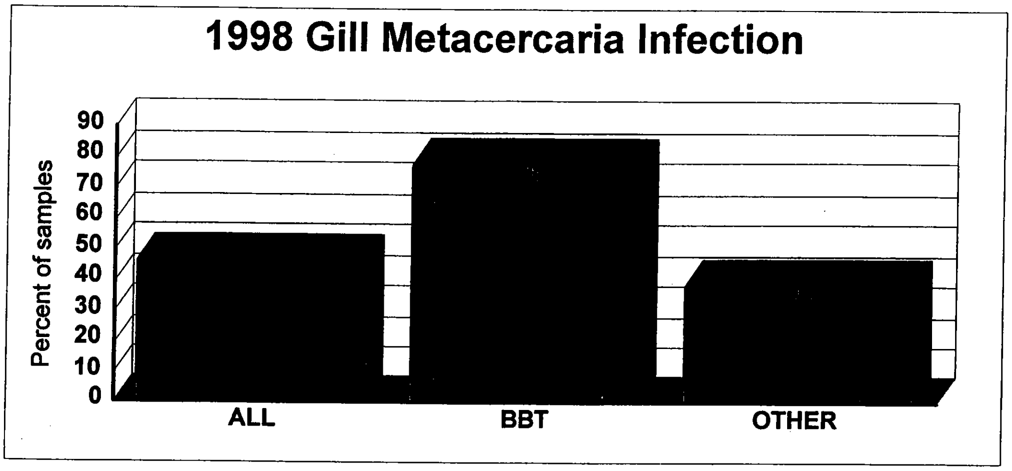


Chart 4. Percentage of smolts with gill metacercarial infection (histological samples) by site. "ALL" represents all gill samples (N=66) from all sites, "BBT" are samples from the Klamath River at the Big Bar Rotary screw trap (N=9), and "OTHER"are samples from the sites other than the BBT site (N=57).

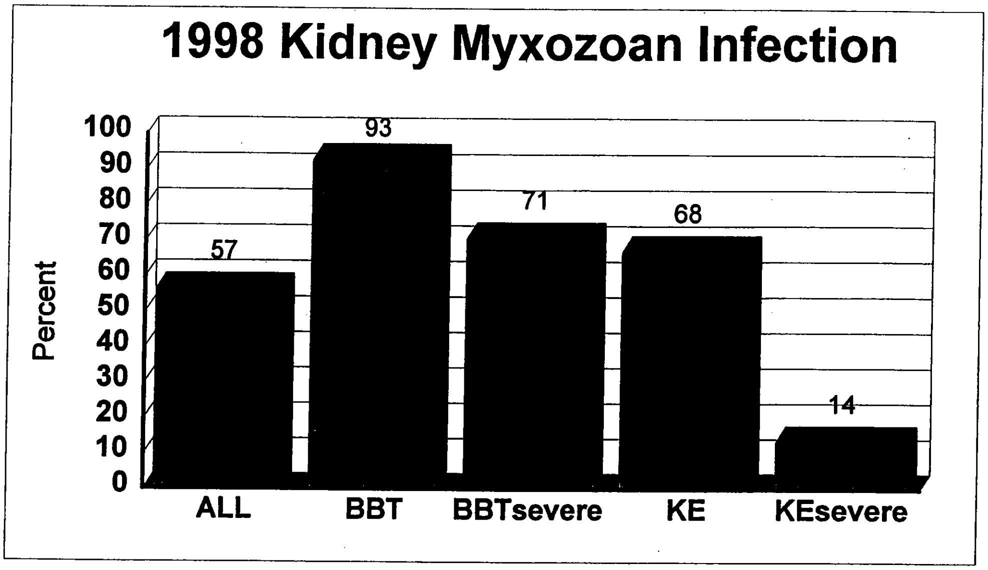


Unidentified Myxozoan Parasite - The previously seen, but unclassified myxozoan parasite was noted by histology again in 1998. Fifty-eight percent of all sampled fish had pre-sporogonic stages of a myxozoan parasite in the glomerulus and tubules of the kidney. Sample sites with the most significant infections were at the Klamath River Big Bar site in July and the Klamath Estuary in August. Ninety-four percent of samples from the Klamath River, Big Bar site had the infection, and 76% were judged "severe" based on their association with tissue damage. Seventy percent of the Klamath Estuary sample kidneys had this infection, but only 23% were considered severe (see chart 5). In contrast, only seven percent of Trinity River captured chinook (from the Weitchepek and Willow Creek rotary screw-trap) had evidence of myxozoan infection. The effect of this parasitic infection and the associated glomerulonephritis on smolt survival is unclear. Mild infections do not appear to impair osmoregulation in saltwater (Appendix 4).

The enteric parasite *Ceratomyxa shasta,,* which in 1995 caused severe infections and mortality in Klamath River chinook, was not often detected in 1998. Sampling bias may have reduced the detection ability in 1998. The Klamath River rotary screw traps were either poorly located or non-functioning during most of August, 1998. Therefore, any *C. shasta* associated health problems may have gone unnoticed. External parasites such as copepods (e.g., *Salmincola)* and glochida (larval mussel stage infection of gill) were also observed in the fish. Copepods were seen on 18% (8 out of 44) of observed gills in the Trinity River chinook and may have predisposed fish to columnaris.

Viral samples did not produced evidence of virus in any samples in this study (no cytopathic effect after 14 days). Sample dates, sites, and results follow: 1) 8/11/98, Trinity River, Willow Creek Trap, 0/10 chinook, 2) 8/24/98 Klamath Estuary, 0/2 steelhead, and 3) 8/31/98, Klamath Estuary, 0/5 chinook.

Chart 5. Myxozoan parasite infection of kidney from all sites (ALL) (N=63), Klamath River at Big Bar site (BBT) (N=14), Klamath Estuary (KE) (N=28), and "severe" infections at those sites when tissue damage was observed.



Water Quality - The Klamath River at river kilometer 81 had dissolved oxygen levels below the acute threshold of 7 mg/L set by the Environmental Protection Agency (1986) for a total of 175 hours over several days between 17 August to 31 August, 1998 (see chart 6). Additionally, dissolved oxygen conditions on both the lower Klamath and Trinity Rivers were below the 8 mg/L standard set by the State of California, North Coast Water Quality Control Board (1993) for most of the month of August. No dissolved oxygen data was collected in September, but similar conditions probably persisted into the first week when air temperatures were above 32^0 Celsius in the Klamath Basin. Dissolved oxygen was expected to be at its worst for fish during the late night or early morning hours of the study period when biological respiration is highest. Unfortunately, additional round-the-clock dissolved oxygen monitoring was not possible on the Klamath River due to a lack of monitoring equipment.

When adverse environmental conditions exist, like high water temperatures, bacteria are more likely to cause serious fish disease. For example, columnaris is more likely to cause problems above 12.7 ^{0}C (Holt et al. 1975) and infections can be explosive above 18 ^{0}C (Warren 1991). Temperatures during this study were above 18 ^{0}C on both the Trinity and Klamath Rivers from July 1, 1998 to September 1st (see chart 7). Klamath River water temperatures were measured in excess of the 20 ^{0} Celcius Environmental Protection Agency standard (1986) for 68% of the time between June 15th and Septmeber 1st, 1998 (53.6 days). Since the dissolved oxygen and temperature conditions measured by the Hydrolab ® and the Onset ® dataloggers were probably similar throughout the lower Klamath River, the performance of fish (swimming capacity, energy reserves, disease resistance) was most likely compromised. Despite the relatively good water flow regime during 1998 compared to the previous 11 years (USGS flow gauging data 1989-1998, see appendix 2), elevated water temperature and low dissolved oxygen are believed to have a role in 1998 fish health problems.

Chart 6. Dissolved Oxygen on the Klamath River at Big Bar Trap (rkm 81) from August 17 through September 1, 1998. (Recorded every 30 minutes).

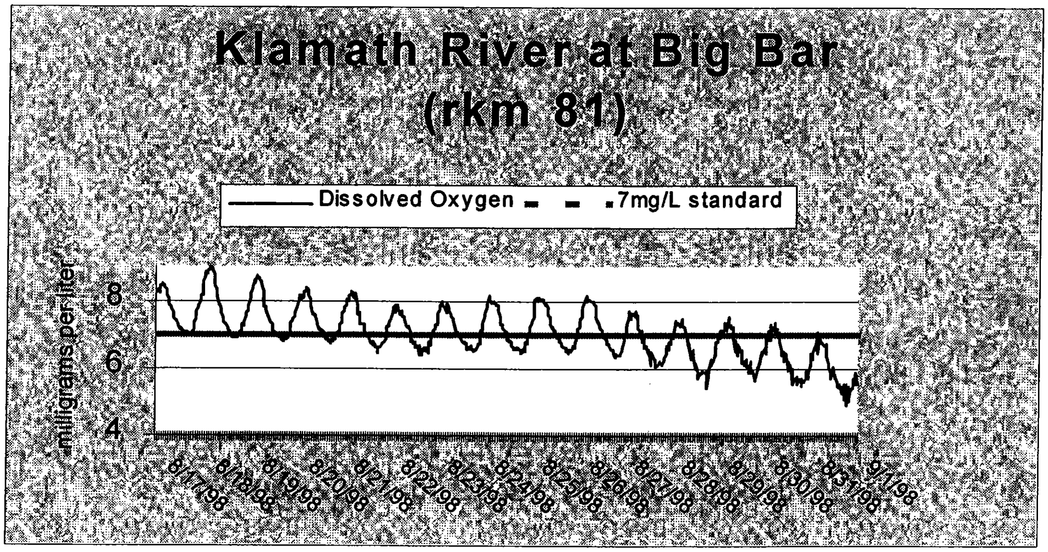
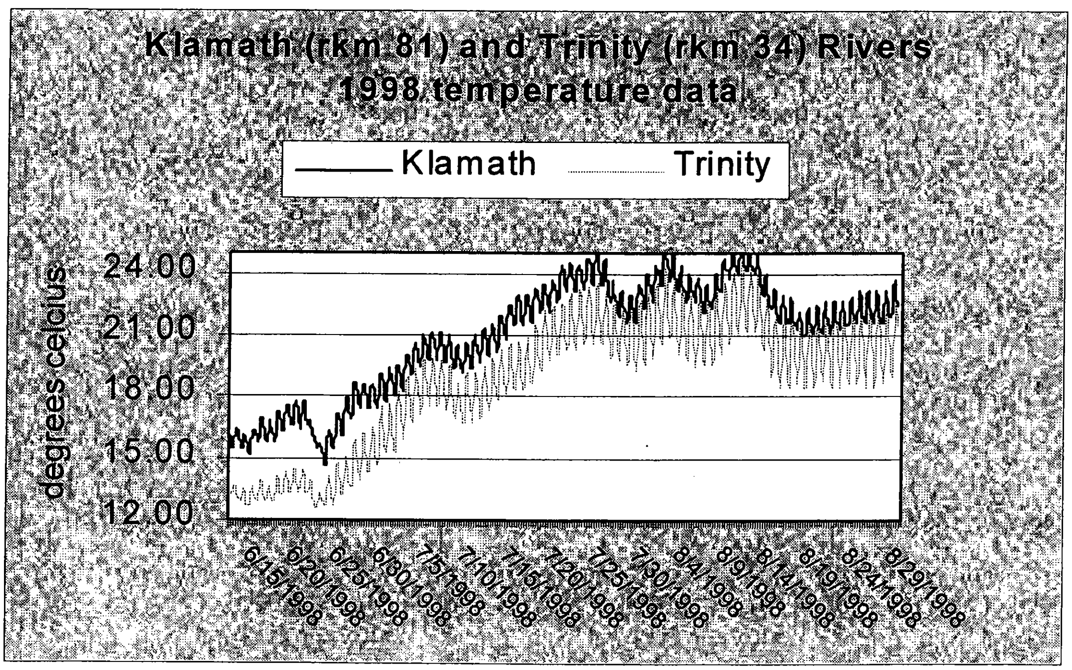


Chart 7. Water Temperatures recorded every two hours at Klamath River at Big Bar (rkm 81) and Trinity River at Willow Creek (rkm34) from June 15 through September 1, 1998.



Discussion and Mortality Estimate

Flavobacterium columnare and *Aeromonas / Pseudomonas* bacteria were responsible for the columnaris and septicemia observed in moribund fish from the lower Klamath Basin during 1998. Columnaris seemed to affect Trinity River chinook more than Klamath River chinook while septicemia was more prevalent in the Klamath Estuary. The elevated temperature and low dissolved oxygen conditions found in this study may have contributed to pathogen infections, disease, and mortality. Parasite infections were not judged to be a significant source of disease in 1998.

Both hatchery and natural fish are infected by a wide array of pathogens throughout their life cycles which may or may not produce disease. In general, fish disease results when a virulent pathogen invades a susceptible host that has been weakened by stressful environmental conditions and is unable to mount a physiological defense. Pathogens like *Flavobacterium columnare* and *Aeromonas / Pseudomonas* species, are opportunistic and always present in the environment. Aeromonads are common microbes in the intestinal tract of salmonids (Ringo et al. 1995). Their abundance is influenced by changes in environmental conditions. Fish disease from these and other pathogens act to weaken the fish and impair its performance or cause direct mortality. Mesa et al. (1998) report an increased predation rate experienced by chinook with BKD. We would expect a similar effect on Klamath Basin chinook undergoing a severe pathogen infection.

Mortality rates between June 15th and September 1st, 1998 were 1.4 and 2.1 % at the respective Fish and Wildlife Service operated Trinity and Klamath river rotary screw traps. Approximately 4.3 million Trinity hatchery and 5.1 million Klamath hatchery chinook were released during the June 15 to September 1 time period (California Department of Fish and Game memorandum, 1998). One point four percent of the Trinity Hatchery chinook population is approximately 61,000 (see table 2). Two point one percent of the Klamath Hatchery chinook population is approximately 107,000.

An estimated 51% of Trinity River Trap caught chinook and 38% of Klamath River Trap caught chinook were of natural origin during the period 6-15-98 to 9-1-98. This translates to an estimated 2,224,412 Trinity and 1,921,424 Klamath river natural origin juvenile chinook. When these population estimates are multiplied by the rotary trap mortality rates, the results are an additional 31,000 and 41,000 natural chinook mortalities in the Trinity and Klamath Rivers respectively. The total mortality estimate for both the Trinity and Klamath Rivers is approximately 240,000.

Table 2. Hatchery and natural origin juvenile chinook population mortality estimate resulting from disease in 1998.

River	Hatchery Release #	Screwtrap % Mortality	Natural Population Estimate	Hatchery Estimate	Natural Estimate	Total
Trinity	4.3 M	1.4	2.2 M	61,000	31,000	92,000
Klamath	5.1 M	2.1	1.9 M	107,000	41,000	148,000
						240,000

Although we assumed the rotary screw trap mortality rate is equal to that of the migrating population, one circumstance makes this assumption unlikely. We did not consider chinook that die upstream or downstream of the traps and are not included in the mortality estimate. This would make our mortality estimate low.

Controlled experiments which establish direct links between environmental stressors (elevated water temperatures and low oxygen) and fish disease would enhance understanding fish health in the Klamath basin. Additionally, 24 hour monitoring of dissolved oxygen and temperature at trapping sites would help our understanding of environmental stressors in the basin.

In appreciation This work would not have been possible without cooperation from the fish trapping crews of the Yurok Tribal Fisheries, Karuk Tribal Fisheries, U.S. Forest Service, and the California Department of Fish and Game.

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Appendix 1. Organosomatic analysis criteria scores

= =

Skin	0 = normal scale number, no lesions
	1 = some scale loss, 11 - 30 % of body surface
	2 = focal hemorrhages, lesions, scale loss >30 % of body
Eye	0 = no abnormalities
	1 = missing 1 eye, diminutive, external abrasion, some opacity
	2 = exophthalmic 'pop-eye', cataract, bubbles, parasites
	3 = hemorrhage, rupture
Gill	0 = normal condition, color
	1 = pale
	2 = clubbed, frayed, nodules, mild parasite load
	3 = necrotic zones, fungi or bacterial lesions, hemorrhagic

Hemor. Organs
Notes about any hemorrhagic organs- abnormal size / color
N = no , Y = Yes

Appendix 2. Annual Average daily Trinity River Flow at Hoopa during October through September with corresponding ranks (1= highest, 11=lowest)

Trinity River Flow at Hoopa USGS station #11530000		
Year	Daily Mean Flow	Index
1998	9313	1
1997	6430	3
1996	6202	4
1995	7825	2
1994	1935	10
1993	5532	5
1992	2035	9
1991	1710	11
1990	2437	8
1989	4303	6
1988	2798	7

Annual Average Daily Klamath River flow at Orleans during October through September with corresponding ranks (1= highest, 11=lowest)

Klamath River at Orleans (USGS station # 11523000)		
Year	Daily Mean Flow	Rank
1998	12764	2
1997	12788	1
1996	10390	4
1995	10769	3
1994	3192	10
1993	9003	5
1992	2931	11
1991	3350	9
1990	4689	7
1989	7589	6
1988	4504	8

Appendix 3. Trematode snail supplementary Information

In September 1996, yearling chinook from Trinity River Hatchery were exposed for 27 days to *Juga sp.* snails carrying an infective stage of the trematode *Nanophyetus salmincola.* Little mortality occurred to the exposure group and all fish became infected with the metacercaria stage of the parasite. Severity of infection ranged from 32 to 10,220 metacercaria per gram of kidney tissue with over 50% of the infected fish having > 5,000 metacercaria / g. No significant difference in blood cell numbers or composition, or plasma concentrations of protein, glucose, and triglyceride was detected between infected and control fish. Infected fish showed an increase in immunoglobulin and a decrease in saltwater osmoregulation ability. This study demonstrates that juvenile chinook can withstand severe infections of *N. salmincola* in freshwater, however, saltwater survival is likely to be impaired. A direct correlation between the number of metacercaria in the kidney (threshold level) and plasma sodium was not identified in the short-term saltwater challenges.

The life cycle of *N. salmincola* starts with the release of eggs from the adult trematode into the intestine of its final host, a piscivore such as an otter, bear, raccoon, heron, merganser, etc, and pass out into the water with feces. . A ciliated miracidium stage hatches from the egg , penetrates a snail host (*Oxytrema = Juga sp.),* asexually multiples, and eventually produces a xiphidiocercaria (cercaria with oral sucker stylus which is motile by use of its tail). The cercaria will seek out a fish host and rapidly burrow into the skin, lose its tail, and migrate through the circulatory system to various tissues such as the gill, heart, liver, muscle, optic nerve, and kidney.

The parasite (now referred to as metacercaria) tends to concentrate in the posterior kidney, probably due to the migration path through the renal portal system (Milleman and Knapp 1970). The metacercaria will remain with the salmonid fish throughout its salt water phase and will complete its lifecycle when the fish is eaten by a final host. The longevity of the metacercarial stage has been used as a biological tag for steelhead caught in the central Pacific ocean (Dalton 1991).

Appendix 4. Salt Water Challenge
Fourteen out of fifteen chinook survived the 80+hour saltwater challenge (see data form ID# 29 in Appendix 2). One out of fifteen fish had lesions associated with a myxosporidian infection. It was assumed that the myxosporidian would be more abundant in the kidneys of sampled chinook in 1998, as in 1997 sampled chinook. No other significant results were found.

Appendix 5. Ceratomyxa shasta
In response to the Ceratomyxosis data gathered in 1995, Mel Willis (CDFG Fish Pathologist) conducted a challenge experiment with Iron Gate Hatchery chinook in July 1996 (August 1, 1996 memo, Appendix). Chinook were held in *C. shasta* infective water source at Crystal Lake State Fish Hatchery for over 40 days (Noble 1950). The temperature of this water source does not exceed 16 ° C. There was no mortality or clinical signs observed in the chinook group. A cohort group of rainbow trout juveniles (Shasta strain which are susceptible to ceratomyxosis) held at the same site developed clinical symptoms and experienced mortalities. Histological examination of several chinook at the end of the challenge did not reveal any *C. shasta* parasites. Iron Gate Hatchery steelhead challenged at the same site for 85 days were also resistant to infection and disease. **When water temperatures are under 16 - 17 °C** , it appears that these Klamath R. salmonids are resistant to this endemic parasite. There are numerous reports of salmonid stocks, native to *C. shasta* infective areas, having innate resistence to ceratomyxosis (Ibarra et al. 1991).

Appendix 6. Data sheets (see pages to follow).

Date: 7/30/1998

Time: 6:45:00 PM

ID #: 1

Site: WCT

Samplers: JW

GPS: N40:59:12.3 W123:38:5.77

Capture Technique: RST

STT mortalities: 0

Total Chinook Catch: 14

Morbid Chinook: 6

Temperature: 22.0

Chinook Mortalities: 7

Dissolved O2-live bo: 0.0

Total Steelhead catc: 0

Morbid STT: 0

Dissolved o2-back of: 14.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
1	7/30/1998	501	80	1	3	0	0	0	☑	DIED SHORTLY AFTER CAPTURE, PALE NECROTIC GILL	23	A/P	
1	7/30/1998	502	87	0	3	0	0	0	☑	DIED SHORTLY AFTER CAPTURE, PALE NECROTIC GILL	0	A/P	
1	7/30/1998	503	91	0	3	0	0	0	☐	COLUMNARIS? PALE NECROTIC GILL	2	A/P	a lot of long GNR
1	7/30/1998	504	86	0	3	0	0	1	☑	COLUMNARIS? PALE NECROTIC GILL	3	A/P	a lot of long GNR
1	7/30/1998	505	85	1	3	0	0	1	☐	COLUMNARIS? PALE NECROTIC GILL	17	A/P	a lot of long GNR
1	7/30/1998	506	89	1	3	0	0	0	☑	COLUMNARIS? PALE NECROTIC GILL	13	DNG	GPC ON CELLS

Date 7/10/1998

ID # 2

Time

Site OC

Samplers JW, TM, LOREN

GPS

Capture Technique RST

STT mortalities 0

Total Chinook Catch 18

Morbid Chinook 2

Temperature 19.5

Chinook Mortalities 8

Dissolved O2-live bo 7.8

Total Steelhead catc 0

Dissolved o2-back of 8.5

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
2	7/10/1998	250	103	0	0	0	0	0	☑		2	A/P	
2	7/10/1998	251	87	1	2	0	0	0	☐		0		lg GNR
2	7/10/1998	252	86	0	0	0	0	0	☑		0	A/P	
2	7/10/1998	253	96	0	0	3	0	0	☑	BLOODY EYE	0	A/P	
2	7/10/1998	254	81	1	1	0	2	0	☐	HEMOR FIN BASE, HCT 13%, PALE KD	0	A/P	
2	7/6/1998	0	0	0		0	0	0	☐		0		
2	7/6/1998	0	0	0		0	0	0	☐		0		
2	7/6/1998	0	0	0		0	0	0	☐		0		

Date 8/6/1998

ID # 3

Time 10:00:00 AM

Site WP

Samplers JW, Dale S. Richard

GPS N41:11:04.77, W123:42:22.39,

Capture Technique RST

STT mortalities 4

Total Chinook Catch 38

Morbid Chinook 3

Temperature 21.0

Chinook Mortalities 29

Dissolved O2-live bo 8.0

Total Steelhead catc 5

Dissolved o2-back of

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
3	8/6/1998	641	89	2	1	0	0	1	☐	wt spots on gill	1	yeast	GPC
3	8/6/1998	642	88	2	1	0	0	2	☐	yel swollen IT	24	A/P	
3	8/6/1998	643	92	2	3	0	0	2	☑	necrotic gill, hemor IT	13	BA/BP	LG GNR

Date	8/5/1998
Time	10:00:00 AM
Site	OC
Samplers	JW, FRANK, CHRIS
GPS	0
Capture Technique	RST
Total Chinook Catch	18
Morbid Chinook	6
Chinook Mortalities	6
Total Steelhead catc	1
Morbid STT	0

ID #	4
STT mortalities	1
Temperature	22.0
Dissolved O2-live bo	0.0
Dissolved o2-back of	7.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
4	8/5/1998	631	80	1	0	0	0	0	☐	bloody c peduncle	0	BA/BP	
4	8/5/1998	632	85	2	0	0	2	0	☑	hemor vent ridge, swollen KD	0	A/P	
4	8/5/1998	633	90	2	0	0	0	0	☑	no food in stomach, blood anus	3	DNG	
4	8/5/1998	634	91	2	0	0	2	0	☑	bloody tail	1	A/P	
4	8/5/1998	635	84	2	0	0	0	0	☐	bloody c peduncle, yel gall blader	0		
4	8/5/1998	636	83	0	0	0	1	0	☐	yell gall bladder	0	Rsal	

Date	7/2/1998
Time	7:30:00 AM
Site	BBT
Samplers	JW
GPS	N41:15:2.87 W123:38:21.87
Capture Technique	RST
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0
ID #	5
STT mortalities	0
Temperature	18.0
Dissolved O2-live bo	8.0
Dissolved o2-back of	9.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
5	7/2/1998	101	82	2	0	0	0	0	☐	ANOREXIC, LAMPREY WOUND	0		
5	7/2/1998	102	92	2	0	0	1	0	☑	DFAT	2	BA/BP	
5	7/2/1998	103	83	2	0	0	0	0	☑		2	BA/BP	
5	7/2/1998	104	96	0	0	0	0	0	☑		0		
5	7/2/1998	105	92	1	0	0	0	0	☑	Trematode seen in KD	0		
5	7/2/1998	106	98	2	1	0	0	1	☐	PALE GILL AND KD, DFAT	0	Rsal- "clinica	
5	7/2/1998	107	85	0	0	0	0	0	☐	PALE KD, DFAT	0		
5	7/2/1998	108	86	0	0	0	0	0	☑		0		
5	7/2/1998	109	91	0	2	0	0	0	☐	GILL ROT ON ONE SIDE	1		
5	7/2/1998	110	95	2	2	0	0	0	☐	GILL ROT, LAMPREY WOUND	0	Long GNR	

Date: 6/22/1998

ID #: 6

Time:

Site: BBT

Samplers: JW

GPS: N41:15:2.87 W123:38:21.87

Capture Technique: RST

Total Chinook Catch: 1007

STT mortalities: 0

Morbid Chinook: 0

Temperature: 62.0

Chinook Mortalities: 7

Dissolved O2-live bo: 10.0

Total Steelhead catc: 0

Dissolved o2-back of: 10.0

Morbid STT: 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
6	6/22/1998	1	89	0	0	0	0	0	☐	DEAD FISH FROM TRAP	0	A/P	

Date	6/22/1998	ID #	7
Time			
Site	OC		
Samplers	HV, PL, FE		
GPS			
Capture Technique	RST	STT mortalities	0
Total Chinook Catch	1007		
Morbid Chinook	0	Temperature	0.0
Chinook Mortalities	7	Dissolved O2-live bo	0.0
Total Steelhead catc	0		
Morbid STT	0	Dissolved o2-back of	0.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
7	6/22/1998	2	91	2		0	0	0	☐	DEAD	0	No Rsal	
7	6/22/1998	3	89	0		0	0	0	☐	DEAD	6	No Rsqal	

Date	8/3/1998
Time	11:00:00 AM
Site	WCT
Samplers	JW
GPS	N40:59:12.3 W123:38:5.77
Capture Technique	RST
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0
ID #	8
STT mortalities	0
Temperature	20.0
Dissolved O2-live bo	8.0
Dissolved o2-back of	9.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
8	8/3/1998	601	72	0	3	0	0	0	☐	ONE SIDE HAS ROTTEN GILL			A LOT OF LONG GNR
8	8/3/1998	602	80	2	3	0	0	0	☑	ONE SIDE HAS ROTTEN GILL, ALSO HEMOR FIN BASE		Columnaris	MOD AMTS LONG GNR
8	8/3/1998	603	83	1	3	0	0	0	☑	COPEPOD UNDER OPERCULUM			
8	8/3/1998	604	94	1	3	0	0	0	☑	HEMOR ON BRANCHIO RAYS, MORBID			
8	8/3/1998	605	85	0	3	0	0	0	☑	YEL SPOTS ON ON GILL	9		ONLY GPC
8	8/3/1998	606	87	0	3	0	0	1	☑	ROTTEN NEAR BASE OF GILL, YEL FUNK ON IT	7	A/P	A LOT OF LONG GNR
8	8/3/1998	607	83	0	3	0	0	0	☑	COPEPOD ATTACHED BELOW JAW	16		LONG GNR, GPC

Date 8/3/1998

ID # 9

Time 12:15:00 PM

Site BBT

Samplers JW

GPS N41:15:2.87 W123:38:21.87

Capture Technique RST

STT mortalities 0

Total Chinook Catch 0

Morbid Chinook 0

Temperature 23.0

Chinook Mortalities 0

Dissolved O2-live bo 9.0

Total Steelhead catc 0

Dissolved o2-back of 9.0

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
9	8/3/1998	611	88	0	0	0	0	0	☐		2		
9	8/3/1998	612	79	1	0	0	1	0	☐	BLOOD ON JAW	1		
9	8/3/1998	613	80	0	0	0	0	0	☑		2		

Date	8/17/1998
Time	11:00:00 PM
Site	KLEST
Samplers	JW, Josh, Patrick, Colin
GPS	N41:32:20.38, W124:04:31.5,
Capture Technique	Eboat
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0

ID #	10
STT mortalities	0
Temperature	22.0
Dissolved O2-live bo	0.0
Dissolved o2-back of	8.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
10	8/17/1998	821	151	3	0	0	0	0	☐	STT, WD sample, red chin, fin base	5	STAP H	
10	8/17/1998	822	94	3	0	0	3	0	☑	Dark skin, red caudal, fins, jaws, mouth	0		
10	8/17/1998	823	98	3	0	0	3	0	☑	bloody tail, red mouth	2	Rsal	
10	8/17/1998	824	97	3	0	3	0	0	☑	boody fin base, tail, swol KD?	0		
10	8/17/1998	825	137	3	0	0	0	0	☑	STT, bloody fin base, roof of mouth, caudal, WD	0	A/P	
10	8/17/1998	826	105	3	0	0	0	0	☑	bloody fin base, caudal, roof of mouth	17	A/P	
10	8/17/1998	827	114	3	0	0	0	0	☑	STT, bright red fins, mouth, caudal, WD sample	0		
10	8/17/1998	828	95	3	0	0	3	0	☑	hemor, fin base, yel gall, no food lower gut	0		

Date	8/10/1998
ID #	11
Time	9:20:00 AM
Site	KLEST
Samplers	JW, Josh, Patrick, Colin, Mike
GPS	N41:32:20.38, W124:04:31.5,
Capture Technique	Bseine
Total Chinook Catch	0
STT mortalities	0
Morbid Chinook	0
Temperature	20.0
Chinook Mortalities	0
Dissolved O2-live bo	0.0
Total Steelhead catc	0
Dissolved o2-back of	7.0
Morbid STT	0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
11	8/10/1998	701	99	3	0	0	0	0	☑	hemor tail	11	DNG	
11	8/10/1998	702	89	0	3	0	0	0	☑	wt spot on gill, #3574	40		FEW GPC
11	8/10/1998	703	85	0	0	0	0	0	☑	#3575	7		
11	8/10/1998	704	88	3	0	0	0	3	☐	bloody caudal and pelvics, only food in lower gut	22	A/P	
11	8/10/1998	705	98	3	0	0	0	0	☑	faint caudal hemor	23		
11	8/10/1998	706	96	0	0	0	0	0	☑	whole KD, #3579	1		
11	8/10/1998	707	91	0	0	0	0	0	☑	whole KD, #3578	32		
11	8/10/1998	708	86	0	3	0	0	0	☑	DFG # 3580	16	DNG	
11	8/10/1998	709	87	0	0	0	0	0	☑	#3581	7		
11	8/10/1998	715	91	3	0	0	0	0	☑	Bloody anus, vent fin	19	A/P	
11	8/10/1998	710	190	3	0	0	0	1	☑	STT, WD, bloody fin base, and caudal hemor faint	1	A/P	
11	8/10/1998	711	95					0	☐	red tint under chin, fat belly	11		
11	8/10/1998	712	96					0	☐	gammurus in stomach, yel gall, pink flesh #3583	2		
11	8/10/1998	713	192	3	0	0		0	☐	CUTT, hemor at fin base, faint red caudal, rounded	2	DNG	
11	8/10/1998	714	0	0	3	0		0	☐		0		

Date: 8/4/1998

ID #: 12

Time: 12:30:00 PM

Site: KLEST

Samplers: JW, Josh, Patrick, Colin

GPS: N41:32:20.38, W124:04:31.5,

Capture Technique: Bseine

Total Chinook Catch: 200

STT mortalities: 0

Morbid Chinook: 0

Temperature: 22.0

Chinook Mortalities: 0

Dissolved O2-live bo: 0.0

Total Steelhead catc: 0

Dissolved o2-back of: 8.0

Morbid STT: 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
12	8/4/1998	621	101	0	0	0	0	1	☑	yel lower IT	8		
12	8/4/1998	622	88	2	0	0	0	0	☑	P.Hemor anal pelvic fins	0		
12	8/4/1998	623	88	2	0	0	0	0	☑	lots of shrimp in IT	13		
12	8/4/1998	624	93	0	0	0	0	0	☑		36		
12	8/4/1998	625	91	0	0	0	0	0	☐	food in lower IT, yel gall	1		

Date	8/11/1998
Time	8:00:00 AM
Site	WCT
Samplers	Rick Harmon, SF, JW
GPS	N40:59:12.3 W123:38:5.77
Capture Technique	RST
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0

ID #	13
STT mortalities	0
Temperature	20.0
Dissolved O2-live bo	7.0
Dissolved o2-back of	8.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
13	8/11/1998	721	85	0	3	0	0	3	☐	COLUMNARIS		Fc+A	
13	8/11/1998	722	92	0	3	0	0	0	☐	COLUMNARIS, COPEPOD, FUNGUS, SPL SWOLLEN		Fc+AP	
13	8/11/1998	723	75	0	3	0	0	0	☑	NECROTIC GILL			
13	8/11/1998	724	99	0	3	0	0	0	☑	NECROTIC GILL		AP	
13	8/11/1998	725	86	3	3	0	0	0	☐	NECROTIC GILL, GLOCHIDIA		Fc+AP	
13	8/11/1998	726	85	3	0	0	0	0	☑	YEL SKIN		AP	
13	8/11/1998	727	85	3	0	0	0	0	☑	YEL SKIN		AP	
13	8/11/1998	728	94	0	3	0	0	0	☑	NECROTIC GILL		AP	
13	8/11/1998	729	91	1	3	0	0	0	☑	GLOCHIDIA			
13	8/11/1998	730	83	0	0	0	0	0	☐		0		

Date	8/14/1998
Time	9:30:00 AM
Site	WP
Samplers	JW, Tim Hayden
GPS	N41:11:04.77, W123:42:22.39,
Capture Technique	RST
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0

ID #	14
STT mortalities	0
Temperature	23.0
Dissolved O2-live bo	8.0
Dissolved o2-back of	9.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
14	8/14/1998	751	91	2	3	0	0	0	☑	wt spots, glochidia, wt transluscent head, dark	1	A/P	
14	8/14/1998	752	90	2	0	0	0	3	☐	PT on thymus, scar between pectorals, hemor IT	0	A/P	

Date 8/17/1998

ID # 15

Time 2:00:00 PM

Site WCT

Samplers JW

GPS N40:59:12.3 W123:38:5.77

Capture Technique RST

Total Chinook Catch 0

STT mortalities 0

Morbid Chinook 0

Temperature 20.0

Chinook Mortalities 0

Dissolved O2-live bo 9.0

Total Steelhead catc 0

Dissolved o2-back of 9.0

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
15	8/17/1998	801	102	1		0	3	0	☐	SWOL KD, wt bulge, 1/2 KD into tube for Elisa			
15	8/17/1998	802	94	0		3	0	0	☐	hemor eye, exopthalmia	1		
15	8/17/1998	803	104	1		3	0	0	☐	cataracts	0		
15	8/17/1998	804	100	0	3	3	0	0	☐	copepod under opercle, necrosis, slight cataract	0		
15	8/17/1998	805	84	0	3	0	0	0	☐	necrotic gill, columnaris	0		
15	8/17/1998	806	86	0		0	0	0	☐		4		
15	8/17/1998	807	0	0		0	0	0	☐		22		
15	8/17/1998	808	0	0		0	0	0	☐		0		
15	8/17/1998	809	0	0		0	0	0	☐		17		
15	8/17/1998	810	0	0		0	0	0	☐		2		
15	8/17/1998	811	139	0		0	0	0	☐	STT, massive necrosis, bloody fin base	28		LG GNR

Date	4/27/1998
Time	
Site	FS Willow Creek Trap
Samplers	JW
GPS	
Capture Technique	RST
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0

ID #	16
STT mortalities	0
Temperature	0.0
Dissolved O2-live bo	0.0
Dissolved o2-back of	0.0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
16	4/8/1998		85	0		0	0	0	☐	RBT	0		
16	4/22/1998			0		0	0	0	☐	CHK	0		
16	4/16/1998		35	0		0	0	0	☐	CHK	0		
16	4/22/1998		30	0		0	0	0	☐	CHK	0		
16	4/22/1998		30	0		0	0	0	☐	CHK	0		
16	4/22/1998		30	0		0	0	0	☐	CHK	0		
16	4/22/1998		30	0		0	0	0	☐	CHK	0		
16	4/22/1998		30	0		0	0	0	☐	CHK	0		
16	4/22/1998		30	0		0	0	0	☐	CHK	0		
16	4/22/1998			0		0	0	0	☐	CHK	0		
16	4/14/1998			0		0	0	0	☐	STICKLEBACK	0		
16	4/14/1998			0		0	0	0	☐	CHK	0		
16	4/9/1998			0		0	0	0	☐	CHK	0		
16	4/23/1998			0		0	0	0	☐	RBT	0		
16	4/17/1998			0		0	0	0	☐	CHK	0		
16	4/17/1998			0		0	0	0	☐	CHK	0		
16	4/21/1998			0		0	0	0	☐	SPKLDACE	0		

Date 8/31/1998

ID # 17

Time 10:00:00 AM

Site WCT

Samplers Mprall, JW

GPS N40:59:12.3 W123:38:5.77

Capture Technique RST

Total Chinook Catch 303

STT mortalities 0

Morbid Chinook 0

Temperature 19.1

Chinook Mortalities 2

Dissolved O2-live bo 7.6

Total Steelhead catc 4

Dissolved o2-back of 8.4

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
17	8/31/1998	1001	112	3	0	0	0	0	☑	COPEPOD? SCAR W/ FUNGUS	19		
17	8/31/1998	1002	99	3	0	0	0	0	☑	TEAR WOUND NEAR ANUS	0		
17	8/31/1998	1003	104	0	0	0	0	0	☐	NO FOOD IN STOMACH, FOOD IN LOWER IT, GALL YEL	28		
17	8/31/1998	1004	110	3	0	0	0	0	☑	COPEPOD ATTACHED NEAR PELVICS, NON STERILE BACTE	55	Staph/ Strepp	

Date 8/31/1998

ID # 18

Time 10:30:00 PM

Site KLEST

Samplers JW, Patrick, Josh, Colin

GPS N41:32:20.38, W124:04:31.5,

Capture Technique Eboat

STT mortalities 0

Total Chinook Catch

Morbid Chinook 0

Temperature 21.5

Chinook Mortalities 0

Dissolved O2-live bo

Total Steelhead catc

Dissolved o2-back of 7.8

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
18	8/31/1998	1021	104	3	3	0	3	0	☑	red fin base, tail, copepod on opercle			
18	8/31/1998	1022	104	3	0	0	0	0	☑	red fin base		yeast	
18	8/31/1998	1023	100	3	0	0	0	0	☑	long lernia type parasite on dorsal			
18	8/31/1998	1024	102	3	0	0	2	0	☑	hemor fin base, fin base			
18	8/31/1998	1025	98	3	0	0	2	0	☑	p. hemor fin base, caudal peduncle			
18	8/31/1998	1026	94	3	0	0	0	0	☑	p hemor, caudal peduncle	1		
18	8/31/1998	1027	101	3	0	0	0	0	☑	p hemor fin base, caudal peduncle, ant KD fixed,	0		
18	8/31/1998	1028	158	3	0	0	0	0	☑	p hemor fin base, caudal peduncle, mouth, burned d	0	F. column	
18	8/31/1998	1029	133	3	0	0	0	0	☑	p hemor fin base, caudal fin mouth	2	A/P	

Date	7/14/1998
Time	2:00:00 PM
Site	BBT
Samplers	JW, RQ
GPS	N41:15:2.87 W123:38:21.87
Capture Technique	RST
Total Chinook Catch	871
Morbid Chinook	0
Chinook Mortalities	23
Total Steelhead catc	5
Morbid STT	0

ID #	19
STT mortalities	2
Temperature	20.5
Dissolved O2-live bo	7.8
Dissolved o2-back of	9.7

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
19	7/14/1998	305	86	3	0	0	0	0	☑	TRAP LESION?	3		
19	7/14/1998	306	85	3	0	0	0	0	☑	SKIN LESION, LAMPREY	0		
19	7/14/1998	307	87	0	0	0	1	0	☐	Cshasta suspect, slightly pale KD	0		
19	7/14/1998	308	88	0	0	0	2	3	☐	liver hemor	0		

Date	7/8/1998
Time	
Site	BBT
Samplers	JW
GPS	N41:15:2.87 W123:38:21.87
Capture Technique	RST
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0

ID #	20
STT mortalities	0
Temperature	19.8
Dissolved O2-live bo	8.0
Dissolved o2-back of	9.2

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
20	7/8/1998	204	85	2	0	0	1	0	☑		2	A/P	
20	7/8/1998	205	76	0	3	0	0	0	☑	NECROTIC GILL	1	A/P	
20	7/8/1998	206	92	0	3	0	0	0	☑		3	A/P	
20	7/8/1998	207	83	1	3	0	1	0	☑		4	F. column	
20	7/8/1998	208	88	0	3	0	0	1	☑	NECROTIC GILL, LIVER PALE	4		
20	7/8/1998	209		0	0	0		2	☐	SWOLLEN PALE			
20	7/8/1998	201		1	0	0	0	0	☑	TAIL ROT	0	A/P	
20	7/8/1998	202		0	0	0	1	1	☐	TAIL ROT	0	A/P	
20	7/8/1998	203	93	1	0	0	0	0	☑		4	A/P	

Date 8/24/1998

Time 9:30:00 AM

ID # 21

Site WCT

Samplers JW

GPS N40:59:12.3 W123:38:5.77

Capture Technique RST

Total Chinook Catch 540

STT mortalities 0

Morbid Chinook 0

Temperature 18.7

Chinook Mortalities 4

Dissolved O2-live bo 7.3

Total Steelhead catc 4

Dissolved o2-back of 8.5

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
21	8/24/1998	901	124	3	3	0	0	0	☐	SUCKER, HEMOR FIN BASE, DORSAL, ECTOPARAS, NECR GI	0		lg GNR
21	8/24/1998	902	121	3		0			☑	AMMOCETE, RED MOUTH, WOUND POSTERIOR VENT OF MOUTH	1	A/P	
21	8/24/1998	903	43	0	3	0	0	0	☐	SOCKEYE, GILL NECROSIS	0		lg GNR
21	8/24/1998	904	91	0	0	0	0	0	☐	FOOD IN LOWER GUT, YEL GALL	9		
21	8/24/1998	905	103	3	3	0	0	0	☑	NECROT GILL	0	F. column	lg GNR
21	8/24/1998	906	101	0	3	0	0	0	☐	NECROTIC GILL, COPEPOD ON GILL, GRN GALL		F. column	lg GNR

Date: 7/8/1998

ID #: 22

Time: 1:00:00 PM

Site: WCT

Samplers: JW

GPS: N40:59:12.3 W123:38:5.77

Capture Technique: RST

Total Chinook Catch: 0

STT mortalities: 0

Morbid Chinook: 0

Temperature: 18.9

Chinook Mortalities: 0

Dissolved O2-live bo: 8.0

Total Steelhead catc: 0

Dissolved o2-back of: 9.2

Morbid STT: 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
22	7/8/1998	210	105			2	0	0	☐	EXOPTHALMIC	0		
22	7/8/1998	211	87			2	0	0	☐	EXOPTHALMIC	0		
22	7/8/1998	212	90	2				0	☐	AMMOCETE, HEMOR SKIN	0	A/P	

Date	7/14/1998
ID #	23
Time	8:40:00 AM
Site	KLEST
Samplers	RQ, JW, JPRALL, PATRICK,
GPS	N41:32:20.38, W124:04:31.5,
Capture Technique	Bseine
Total Chinook Catch	0
STT mortalities	0
Morbid Chinook	0
Temperature	19.8
Chinook Mortalities	0
Dissolved O2-live bo	
Total Steelhead catc	0
Dissolved o2-back of	8.5
Morbid STT	0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
23	7/14/1998	301	105	2	0	0	0	3	☐	yel int	4		
23	7/14/1998	302	96	3	0	0	1	1	☐	fungus'd tail pale kd	4		
23	7/14/1998	303	93	1	0	0	0	0	☑	KD pale	9		
23	7/14/1998	304	93	0	0	0	0	0	☑		2		

Date 7/18/1998

ID # 24

Time

Site WP

Samplers JW, TM, LOUISA, RICHARD,

GPS N41:11:04.77, W123:42:22.39,

Capture Technique RST

STT mortalities 1

Total Chinook Catch 165

Morbid Chinook 0

Temperature 18.6

Chinook Mortalities 2

Dissolved O2-live bo

Total Steelhead catc 1

Dissolved o2-back of 10.1

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
24	7/18/1998	381	86	0	0	0	0	0	☑		0		
24	7/18/1998	382	85	0	0	0	0	0	☑		0		
24	7/18/1998	383	88	0	0	0	0	0	☑		1		
24	7/18/1998	384	91	0	0	0	1	0	☑	PALE KD	16		
24	7/18/1998	385	80	0	0	0	0	0	☑		8		

Date 7/21/1998

ID # 25

Time

Site KLEST

Samplers RQ

GPS N41:32:20.38, W124:04:31.5,

Capture Technique Bseine

Total Chinook Catch 0

STT mortalities 0

Morbid Chinook 0

Temperature 20.3

Chinook Mortalities 0

Dissolved O2-live bo

Total Steelhead catc 0

Dissolved o2-back of

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
25	7/21/1998	400	95	2	0	0	0	0	☐	BLOODY PELVIC FINS	3		
25	7/21/1998	401	110	2	0	0	0	0	☐	BLOODY PELVIC FINS	1		
25	7/21/1998	402	94	0	0	0	0	0	☐	SWOLLEN VENT	0		
25	7/21/1998	403	84	2	0	0	0	0	☑	BLOODY PELVIC FINS, SWOLLEN VENT	3		
25	7/21/1998	404	89	2	0	0	0	0	☐	BLOODY PELVIC AND ANAL FINS	0		

Date 7/21/1998

ID # 26

Time

Site BBT

Samplers RQ

GPS N41:15:2.87 W123:38:21.87

Capture Technique RST

Total Chinook Catch 0

STT mortalities 0

Morbid Chinook 0

Temperature 23.0

Chinook Mortalities 0

Dissolved O2-live bo

Total Steelhead catc 0

Dissolved o2-back of

Morbid STT 0

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
26	7/21/1998	410	89	2	0	0	0	0	☑	LG OPEN WOUND POSTER OF DORS, BLDY ANAL & PECT FIN	0		
26	7/21/1998	411	86	0	0	0	0	0	☑	MORBID	0		
26	7/21/1998	412	89	2	0	0	0	0	☑	BLOATED WITH WOUND ON STOMACH, looks like BKD	5		
26	7/21/1998	413	86	2	3	0	0	0	☑	WOUND ON GILL, SOME FUNGUS	0		FEW LG GNR
26	7/21/1998	414	87	2	3	0	0	0	☑	WOUND ON GILL, SOME FUNGUS	1		

Date	8/24/1998
Time	11:30:00 PM
Site	KLEST
Samplers	JW
GPS	N41:32:20.38, W124:04:31.5,
Capture Technique	Eboat
Total Chinook Catch	0
Morbid Chinook	0
Chinook Mortalities	0
Total Steelhead catc	0
Morbid STT	0

ID #	27
STT mortalities	0
Temperature	21.0
Dissolved O2-live bo	6.3
Dissolved o2-back of	

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter.	Gill Imprint
27	8/24/1998	921	106	3	0	0	3	0	☑	BLDY UPR JAW, HEMOR CAUDAL PED, FINS	19		
27	8/24/1998	922	103	3	0	0	3	3	☑	PT HEMOR FIN BASE, CAUDAL REGIO, BLACK ECTOPARA	15	A/P	
27	8/24/1998	923	153	3	0	0	0	0	☑	PT HEMOR FIN BASE, CAUDAL REGIO, RED LIPS	14	A/P	
27	8/24/1998	924	100	3	0	0	3	0	☑	PT HEMOR CAUDAL PED PLUS JAWLINE, WT SPOTS IN KD	0	STAP H/STR	
27	8/24/1998	925	96	3	0	0	0	0	☑	PT HEMOR CAUDAL PED PLUS JAWLINE, WT SPOTS IN KD	0		
27	8/24/1998	926	96	3	0	0	0	0	☑	PT HEMOR FIN BASE, CAUDAL PED	22		
27	8/24/1998	927	155	3	0	0	0	0	☑	PT HEMOR FIN BASE, CAUDAL EDGES LIPS	0		
27	8/24/1998	928	149	3	0	0	0	0	☑	PT HEMOR FIN BASE, CAUDAL EDGES LIPS	0		

Date	8/20/1998	ID #	28
Time			
Site	FWS Warehouse		
Samplers	JW		
GPS			
Capture Technique		STT mortalities	0
Total Chinook Catch	15		
Morbid Chinook	0	Temperature	18.6
Chinook Mortalities	12	Dissolved O2-live bo	5.2
Total Steelhead catc	0		
Morbid STT	0	Dissolved o2-back of	

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
28	8/20/1998	831	86	0		0	0	0	☐	94	0		
28	8/20/1998	832	83	0		0	0	0	☐	91	0		
28	8/20/1998	833	79	0		0	0	0	☐	86	0		
28	8/20/1998	834	83	0		0	0	0	☐	89	0		
28	8/20/1998	835	78	0		0	0	0	☐	86	0		
28	8/20/1998	836	93	0		0	0	0	☐	101	0		
28	8/20/1998	837	94	0		0	0	0	☐		0		
28	8/20/1998	838	83	0		0	0	0	☐	91	0		
28	8/20/1998	839	0	0		0	0	0	☐		0		
28	8/20/1998	840	87	0		0	0	0	☐		0		
28	8/20/1998	841	96	0		0	0	0	☐	100	0		
28	8/20/1998	842	90	0		0	0	0	☐	99	0		
28	8/20/1998	843	109	0		0	0	0	☐	114, wt6.7	0		
28	8/20/1998	844	98	0		0	0	0	☐	104, wt15.1	0		
28	8/20/1998	845	84	0		0	0	0	☐	92,wt10.4	0		

Date	8/27/1998	ID #	29
Time			
Site	Warehouse		
Samplers	JW		
GPS			
Capture Technique			
Total Chinook Catch	15	STT mortalities	0
Morbid Chinook	0	Temperature	17.6
Chinook Mortalities	1	Dissolved O2-live bo	7.7
Total Steelhead catc	0	Dissolved o2-back of	
Morbid STT	0		

Data table

ID	Date	Fish No	FL	Skin	Gill	Eye	Kid	Inte	Food pr	Notes	# TN	Bacter	Gill Imprint
29	8/27/1998	951	105	1	0	0	0	0	☐	pt hemor fin base	0		
29	8/27/1998	952	95	0	0	0	3	0	☐		0		
29	8/27/1998	953	110	0	0	0	3	0	☐		0		
29	8/27/1998	954	108	0	0	0	0	0	☐		0		
29	8/27/1998	955	110	0	0	0	0	3	☐		0		
29	8/27/1998	956	107	0	0	0	0	0	☐		0		
29	8/27/1998	957	113	0	0	0	0	0	☐	hemor caudal	0		
29	8/27/1998	958	115	1	0	0	0	0	☐	hemor caudal	0		
29	8/27/1998	959	110	3	0	0	0	0	☐	hemor fin base, caudal peduncle	0		
29	8/27/1998	960	103	0	0	0	0	0	☐	hemor fin base, caudal peduncle	0		
29	8/27/1998	961	112	0	0	0	0	0	☐	hemor fin base, caudal peduncle	0		
29	8/27/1998	962	103	0	0	0	0	0	☐	hemor fin base, caudal peduncle	0		
29	8/27/1998	963	113	3	0	0	0	0	☐		0		
29	8/27/1998	964	100	0	0	0	0	0	☐		0		
29	8/27/1998	965	0	0	0	0	0	0	☐		0		